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Research Article

The Relationship Between Medial and Lateral Tibial Translation and Anterior Cruciate Ligament Injuries

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Abstract

Objectives: We aimed to determine the relationship between medial and lateral anterior tibial translation (ATT) and anterior cruciate ligament (ACL) injury.

Methods: This cross-sectional study analyzed 312 patients who underwent knee magnetic resonance imaging (MRI) with a prediagnosis of ACL rupture between January 2018 and December 2018. 33 patients were excluded from the study. The ATT of both medial and lateral compartments was measured on T1-weighted sagittal images. All MRI images were evaluated by a musculoskeletal radiologist and an orthopedic surgeon. Mid-sagittal planes were used to assess the ATT in both the medial and lateral compartments.

Results: The interclass correlation coefficient (ICC) values for medial and lateral ATT were 0.999 and 0.997, respectively. There was a significant statistical difference between ACL-ruptured and non-ruptured groups according to medial and lateral ATT measurements ($p<0.001$). The difference between sexes for medial ATT values was significant ($p=0.004$). ROC analysis showed that a lateral ATT value of 4.195 mm indicated a sensitivity of 0.726 and a specificity of 0.31.

Conclusion: As a result of an ACL injury, ATT occurs in both the medial and lateral compartments. The agreement between readers regarding medial ATT and lateral ATT measurements was almost perfect. Static MR images may also be useful in the interpretation of secondary signs of ACL rupture.

Keywords: Anterior cruciate ligament, anterior tibial translation, knee

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The anteroposterior stability of the knee joint depends on the integrity of the anterior cruciate ligament (ACL).[1] An ACL tear is a common injury, and its incidence is estimated at 43.5 per 100.000 persons in the United States.[2] ACL disruption causes alterations in knee kinematics, which causes long-term functional impairment.[3] In the intact knee, the anterior tibial translation (ATT) is about 2 mm, and its value increases with different flexion angles under load.[4] In an ACL-ruptured knee, 134 N of the anterior load increases the ATT up to 15 mm at 30° of flexion.[5] Magnetic resonance imaging (MRI) is a useful method for detecting an acute ACL tear.[6] MRI also can be useful for detecting ATT at the medial and lateral compartments. Previous studies have demonstrated that ATT is an important indirect sign of an ACL rupture.[7] An ACL tear results in an ATT with respect to the femur and one that is 5 mm or more of the ATT on MRI has a sensitivity of 86% and a specificity of 99% for an ACL tear.[8]

In this study, we aimed to demonstrate the presence of ATT on MRI in ACL-ruptured and ACL-intact knees, both in the medial and lateral compartments. We also examined interobserver reliability in interpreting ATT values.

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Methods

Patients

This cross-sectional study was approved by the Institutional Review Board. The ethics committee has waived the informed consent from each patient because of the study design. We retrospectively performed a search in our electronic medical records for patients who underwent knee MRI with a prediagnosis of ACL rupture between January 2018 and December 2018. A total of 312 patients were identified. Patients younger than 21 years and older than 50 years were excluded to eliminate immature skeletal structure and potential osteoarthritic degenerative changes. Other exclusion criteria were as follows: any bone and soft tissue tumors, a history of knee infection, previous knee surgery, and any motion artifacts. All MRI images were evaluated by a musculoskeletal radiologist with 14 years of experience and an orthopedic surgeon with 23 years of experience. Based on these criteria, 33 patients were excluded from the study. There were 48 males and 14 females in the patient group, and 119 males and 98 females in the control group. The mean age was 31.9±9.0 years for the patient group and 35.7±8.3 years for the control group.

MRI Protocol and Measurements

A 1.5 T magnetic resonance machine (Magnetom Essenza, Siemens, Erlangen, Germany) with an 8-channel knee coil was used. MRI images were evaluated using the picture archiving and communication system at our institution. The standard knee protocol was used and comprised a coronal PDW (TR: 2350 ms, TE: 26 ms, matrix: 205×256, FOV: 180 mm, slice thickness: 3.5 mm, interslice gap: 0.7 mm, ETL: 69, NEX: 1); a sagittal PDW (TR: 2670 ms, TE: 24 ms, matrix: 205×256, FOV: 190 mm, slice thickness: 3.5 mm, interslice gap: 0.7 mm, ETL: 70, NEX: 1); a sagittal T1-weighted (T1W) (Repetition time [TR]: 515 ms, Echo time [TE]: 14 ms, Matrix: 192×256, field of view [FOV]: 160 mm, slice thickness: 3.5 mm, interslice gap: 0.7 mm, echo train length [ETL]: 55, number of excitations [NEX]: 2); and an axial proton density weighted (PDW) (TR: 2500 ms, TE: 28 ms, matrix: 206×256, FOV: 170 mm, slice thickness: 3.5 mm, interslice gap: 0.7 mm, ETL: 69, NEX: 1). All patients were in the supine position with the knee in slight flexion (10°–15°).

The ATT of both medial and lateral compartments was measured on T1-weighted sagittal images. Two tangential lines were drawn perpendicular to the medial and lateral tibial plateau, and femoral condyle. The distance between these lines represented the ATT of the medial and lateral compartments (Fig. 1). Mid-sagittal planes were used to assess the ATT in both the medial and lateral compartments.

Statistical Analysis

After data collection, statistical calculations were performed using IBM SPSS statistics for Windows V.20 (IBM Corp). The homogeneity of the data distribution was determined by performing the Kolmogorov–Smirnov test. Interobserver

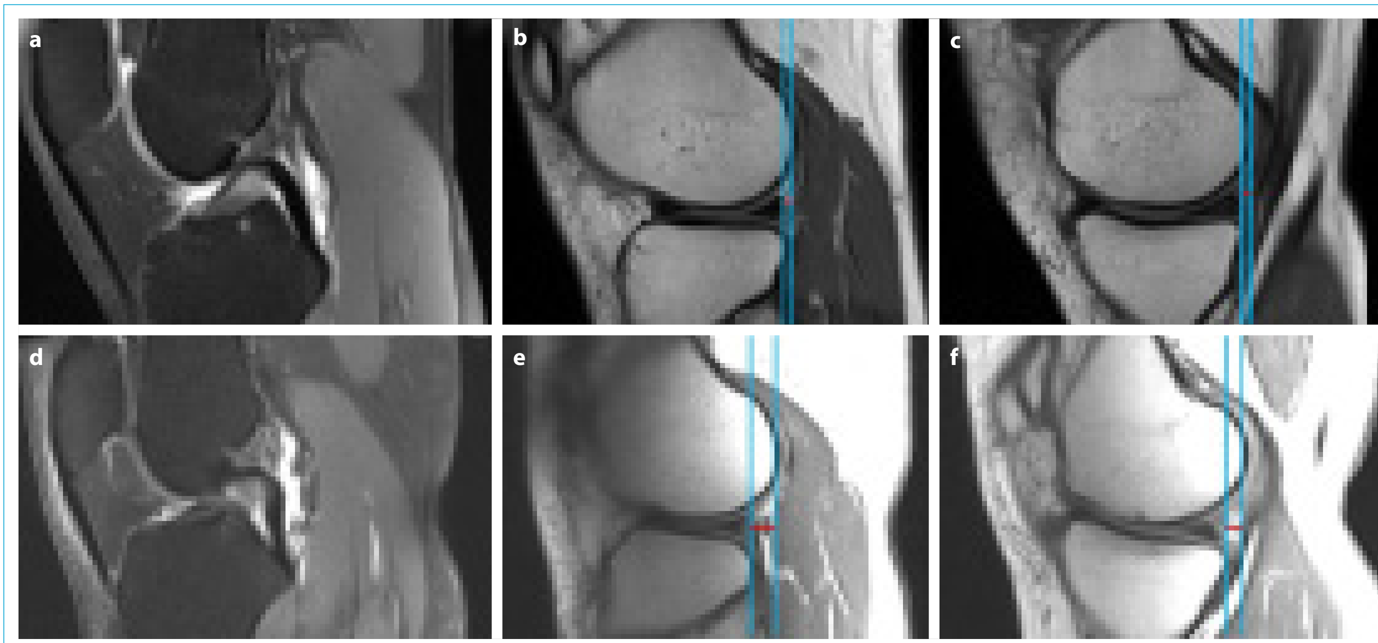

Figure 1. A and **D** represent an anterior cruciate ligament (ACL)-intact and ACL-ruptured knees, respectively. **B** and **E** reveals the measurement of anterior tibial translation in the lateral compartment of the ACL-intact and ACL-ruptured knees, whereas **C** and **F** show this measurement in the medial compartment.

agreement regarding the assessment of ATT by both reviewers was determined by interclass correlation. The interclass correlation coefficient (ICC) values 0–0.20 accepted as "no agreement," 0.21–0.39 showed "minimal agreement," 0.40–0.59 presented "weak agreement," 0.60–0.79 showed "moderate agreement," 0.80–0.90 accepted as "strong agreement," and ICC levels >0.90 indicated "almost perfect" agreement.

Receiver operating characteristics (ROC) were used to indicate a possible cut-off value of lateral and medial ATT values, which might be used in the determination of ACL injury and area under curve (AUC) values, were calculated for both lateral and medial ATT measurement results. The significance of the difference between ACL injured and non-injured individuals was revealed using independent samples t-test and Mann–Whitney U test for the lateral ATT and medial ATT values, respectively. P values of <0.05 were considered significant in statistical analyses.

Results

The ICC value for lateral ATT measurements was 0.997. In addition, the ICC was calculated as 0.999 for medial ATT measurements, and both ICC values revealed an almost perfect agreement between reviewers.

According to the independent samples t-test, there was a significant statistical difference between ACL-ruptured and non-ruptured groups according to lateral ATT measurements (p<0.001) (Table 1).

Kolmogorov–Smirnov tests indicated that there was a non-homogenous data distribution for medial ATT measurement results and a Mann–Whitney U test was performed to calculate the differences between patient and control groups. According to the test results, there was a statistically significant difference between ACL-ruptured and non-ruptured individuals (p<0.001).

Sex differences were calculated for the control group, and there was no significant difference between males and females according to lateral ATT measurements (p=0.969); however, there was a significant difference between sexes for medial ATT values (p=0.004) (Table 1).

ROC analysis showed that a lateral ATT value of 4.195 mm indicated a sensitivity of 0.726 and a specificity of 0.31, which were indicative of an ACL rupture with an AUC value of 0.823 (Fig. 2).

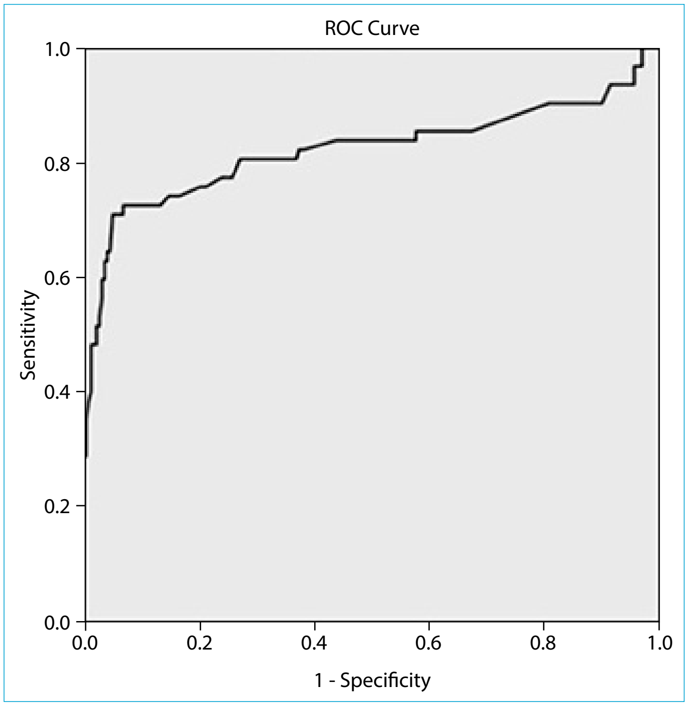

Figure 2. Receiver operating characteristics for lateral anterior tibial translocation measurement results. ROC: Receiver operating characteristics.

Table 1. Mean and standard deviation of patients and control groups

	n	Mean* or Median# values	Standard deviationα or max/minβ values	p
Age (patient group)	62	31.95*	9.08α	0.020
Age (control group)	217	35.70*	8.35α	
Lateral ATT (patient group)	62	5.56*	3.79α	<0.01
Lateral ATT (control group)	217	1.31*	2.17α	
Medial ATT (patient group)	62	2.57#	−2.22/12.30β	<0.01
Medial ATT (control group)	217	0.82#	−4.92/5.19β	
Lateral ATT (males in control group)	119	1.73*	2.03α	0.969
Lateral ATT (females in control group)	98	0.80*	2.11α	
Medial ATT (males in control group)	119	0.87#	−3.43/5.19β	0.004
Medial ATT (females in control group)	98	0.54#	−4.92/3.88β	

ATT: Anterior tibial translocation; patient group: patients with ACL injury; control group: patients with intact ACL; n: number of patients; *: Mean value of the parametric test; #: Median value of the non-parametric test); α: Standard deviation value for parametric test; β: Maximum and minimum values used in the non-parametric test.

Discussion

This study analyzes the relationship between medial and lateral tibial translation and ACL injury and confirms the results of previous studies. In addition, when interobserver agreements were analyzed, there was almost perfect agreement between readers regarding medial ATT and lateral ATT measurements.

The ATT is demonstrated in both ACL-intact and ACL-deficient knees in different biomechanical studies. In the study by Herbort et al., it was shown that in an ACL-intact knee under anterior tibial load, the ATT value was 4.0 mm at 0º of knee flexion and they obtained higher ATT values with different flexion angles. When the ACL was sectioned, this value becomes 7.6 mm at 0° of knee flexion. The ATT was highest at 30º of flexion in both ACL-intact and ACL-sectioned knees.[9] In a biomechanical model that used EMGs, the authors found an increase in ATT values throughout the stance phase for the ACL-ruptured knee compared with the healthy knee. They also found that increasing the tibial slope would increase the resulting ATT.[10] The study by Shefelbine et al. demonstrated the effects of an ACL tear on both meniscal and bone kinematics with an axial load applied to the foot. In this 3D, MR-based technique, the authors enabled a better understanding of the kinematics of the ACL-deficient knee from extension to flexion under an axial load.[11] In addition, other studies assessed axial rotation using cine MRI. However, the authors were unable to demonstrate the alteration of the screw home mechanism. The impairment of this screw home mechanism might be too small to reveal according to the authors.[12] Most studies in the literature are dynamic and performed with the knee in different flexion angles. In this current study, MRI examinations were performed with slight flexion of the knee joint. The anterior translation was assessed at both the medial and lateral compartments and was similar to previous studies. We found a close relationship between the ATT and ACL-ruptured knees. We also learned that the anterior translation occurs in the medial compartment and the difference was significant compared with ACL-intact knees.

Additional MR studies have evaluated measurements of the degree of the ATT to predict ACL rupture. Chen et al.[13] found significantly lower ATT in the acute ACL-injured knee in comparison with the chronic ACL-injured knee. In another study, the authors reported that subluxation of 5 mm or more had 58% sensitivity, 93% specificity, and 69% accuracy for an ACL tear.[14] They also found that completely ruptured ACL knees had a subluxation of 7 mm or more. Özkan et al.[15] concluded that the evaluation of secondary findings such as an ATT might enable a provider to make the correct diagnosis, particularly in chronic ACL-deficient patients. In their report, the average ATT in ACL-deficient knees was 6.1 mm. In a recent study, the authors found a significant correlation between ATT and age, which might increase the false-positive rate for diagnosing ACL tears in the younger population. The cut-off values were 3.5 and 5.5 mm for partial and complete ACL tears, respectively.[16]

Our study has some limitations. Only MRI results were considered in the diagnosis of an ACL tear. Arthroscopic verification should provide more accurate results to differentiate partial from complete tears. There was a significant age difference between patient and control groups. This difference might be attributed to the study design (cross-sectional), and this should be considered before generalizing the results to the entire population. Another limitation was that the MR examinations were performed with the patient in a static position while MR examinations during axial load or in different flexion angles could affect the results. Also, anatomical risk factors such as posterior tibial slope were neglected.

Conclusion

ATT occurs in both the medial and lateral compartments of the ACL-deficient knee. The differences are significant in static images as much as in dynamic studies. Clinicians use static MR images to assess ACL injury and secondary signs instead of dynamic MR images. We believe that static MR images may also be useful in the interpretation of secondary signs of ACL rupture.

Disclosures

Ethics Committee Approval: The Kafkas University Faculty of Medicine Ethics Committee granted approval for this study on February 27, 2019, no: 80576354-050-99/55.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – G.R.U., V.K.; Supervision – G.R.U.; Materials – G.R.U., V.K.; Data collection&/or processing – G.R.U., V.K.; Analysis and/or interpretation – G.R.U., V.K.; Literature search – G.R.U.; Writing – G.R.U.; Critical review – G.R.U., V.K.

References

1. Levine JW, Kiapour AM, Quatman CE, Wordeman SC, Goel VK, Hewett TE, et al. Clinically relevant injury patterns after an anterior cruciate ligament injury provide insight into injury mechanisms. Am J Sports Med 2013;41:385–95. [CrossRef]
2. Mall NA, Chalmers PN, Moric M, Tanaka MJ, Cole BJ, Bach BR et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. Am J Sports Med 2014; 42:2363–70. [CrossRef]
3. Gillquist J, Messner K. Anterior cruciate ligament reconstruction and the long-term incidence of gonarthrosis. Sports Med

1999;27:143–56. [CrossRef]
4. Markolf KL, Mensch JS, Amstutz HC. Stiffness and laxity of the knee the contributions of the supporting structures. A quantitative in vitro study. J Bone Joint Surg Am 1976;58:583–94.
5. Zantop T, Herbort M, Raschke MJ, Fu FH, Petersen W. The role of anteromedial and posterolateral bundles of the anterior cruciate ligament in anterior tibial translation and internal rotation. Am J Sports Med 2007;35:223–7. [CrossRef]
6. Vahey TN, Broome DR, Kayes KJ, Shelbourne KD. Acute and chronic tears of the anterior cruciate ligament: differential features at MR imaging. Radiology 1991;181:251–3. [CrossRef]
7. Van Dyck P, Gielen JL, Vanhoenacker FM, Wouters K, Dossche L, Parizel PM. Stable or unstable tear of the anterior cruciate ligament of the knee: an MR diagnosis? Skeletal Radiol 2012;41:273–80. [CrossRef]
8. Chan WP, Peterfy C, Fritz RC, Genant HK. MR diagnosis of complete tears of the anterior cruciate ligament of the knee: importance of anterior subluxation of the tibia. AJR Am J Roentgenol 1994;162:355–60. [CrossRef]
9. Herbort M, Lenschow S, Fu FH, Petersen W, Zantop T. ACL mismatch reconstructions: influence of different tunnel placement strategies in single-bundle ACL reconstructions on the knee kinematics. Knee Surg Sports Traumatol Arthrosc 2010;18:1551–8. [CrossRef]
10. Shao Q, MacLeod TD, Manal K, Buchanan TS. Estimation of ligament loading and anterior tibial translation in healthy and ACL-deficient knees during gait and the influence of increasing tibial slope using EMG-driven approach. Ann Biomed Eng 2011;39:110–21. [CrossRef]
11. Shefelbine SJ, Ma CB, Lee KY, Schrumpf MA, Patel P, Safran MR et al. MRI analysis of in vivo meniscal and tibiofemoral kinematcis in ACL-deficient and normal knees. J Orthop Res 2006;24:1208–17. [CrossRef]
12. Barrance PJ, Williams GN, Snyder-Mackler L, Buchanan TS. Altered knee kinematics in ACL-deficient non-copers: a comparison using dynamic MRI. J Orthop Res 2006;24:132–40.
13. Chen J, Gu A, Jiang H, Zhang W, Yu x. A comparison of acute and chronic anterior cruciate ligament reconstruction using LARS artificial ligaments: a randomized prospective study with a 5-year follow up. Arch orthop Trauma Surg 2015;135:95–102.
14. Vahey TN, Hunt JE, Shelbourne KD. Anterior translocation of the tibia at MR imaging: a secondary sign of anterior cruciate ligament tear. Radiology 1993;187:817–9. [CrossRef]
15. Özkan İ, Çullu E, Şavk Ö, Aydoğdu S, Alparslan B. Akut ve kronik ön çapraz bağ lezyonlarında sekonder manyetik rezonans görüntüleme bulguları. Acta Orthop Traumatol Turc 2000;34:28–33.
16. Numkarunarunrote N, Chaitusaney T. Anterior tibial translation sign: factors affecting interpretation of anterior cruciate ligament tear. J Med Assoc Thai 2015;98 Suppl 1:S57–62.